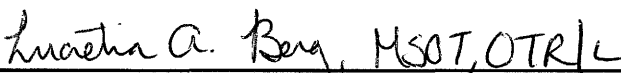
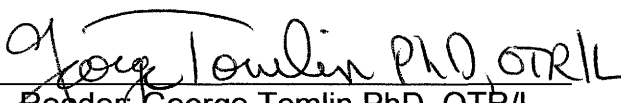


Measuring Outcomes for Pediatric mCIMT:
A Systematic Review

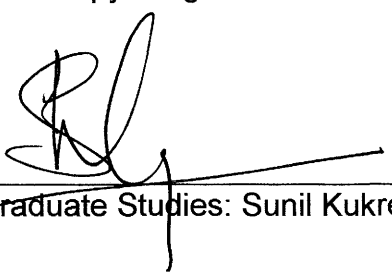
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This research, submitted by Alison Sheehan has been approved and accepted
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Abstract

The purpose of this systematic review was to determine the most appropriate outcome measures for two groups of children ages 4-7, 8-12 (younger and older) with upper extremity hemiparesis resulting from various diagnoses participating in a three week modified constraint-induced movement therapy (mCIMT) camp. A literature review was conducted to identify outcome measures used to assess mCIMT. Outcome measures were included in the review if they were standardized and appeared in at least two studies. A total of 15 outcome measures were included in the review and categorized into three groups, Areas of Occupation, Performance Skills, and Body Function, based on the second edition of the American Occupational Therapy Association (AOTA) Practice Framework. Psychometric properties and characteristics, such as age range and diagnosis, were used to assign points to each outcome measure. Based on the protocol of this study, the outcome measures suggested to assess a mCIMT camp were the ABILHAND-Kids to measure Areas of Occupation, the Melbourne Assessment of Unilateral Upper Limb Function (MUUL) and the Quality of Upper Extremity Skills Test (QUEST) depending on age for Performance Skills, and grip strength with a dynamometer to measure Body Function. Variation in mCIMT protocols and outcome measures made it difficult to compare measures. A more consistent use of outcome measures and protocols in future studies could increase the ability to compare effectiveness of outcome measures.

Measuring Outcomes for Pediatric mCIMT: A Systematic Review

Constraint-induced movement therapy (CIMT) has become a more common therapy for a variety of populations, including those with cerebral palsy, obstetric brachial plexus palsy, and hemiparesis resulting from stroke (Case-Smith, DeLuca, Stevenson, & Landesman Ramey, 2012). Although the word “constraint” can have negative connotations, in this case it is used to help individuals with a one-sided weakness increase the use of their affected arm. Constraint-induced movement therapy involves casting or splinting the unaffected upper extremity in order to promote active use of an involved or injured upper extremity in repeated therapeutic activities. Different protocols have been proposed for duration of daily constraint, how long the constraint will be worn (weeks or months), and type of constraint. Despite varying schedules of constraint, all CIMT programs promote unimanual skills to increase bilateral hand use (Sakzewski, Ziviani, & Boyd, 2010).

Many studies have been done on the effectiveness of modified CIMT (mCIMT) for pediatric populations, however, the outcome measures were inconsistent across studies (Hoare, Wasiak, Imms, & Carey, 2009). Studies with similar protocols could be compared to determine the impact of mCIMT using a larger sample, however, the variation in outcome measures used does not provide uniform data for comparison. Differences in protocols for mCIMT may explain the selection of the varied measures used in these studies including: the Assisting Hand Assessment (AHA), the Child Arm Use Test (CAUT), goniometry for passive range of motion (PROM) and active range of motion (AROM), the Jebsen-Taylor Hand Function Test (JTHFT), the Melbourne Assessment of Unilateral Upper Limb Function (MUUL), the Pediatric Motor Activity Log (PMAL), and video analysis, and others not listed here (Aarts, Jongerius, Geerdink, van

Limbeek, & Geurts, 2011; Eliasson, Shaw, Pontén, Boyd, & Krumlinde-Sundholm, 2009; Hoare et al., 2009; Sakzewski et al., 2010; Taub, Ramey, DeLuca, & Echols, 2004).

This inconsistency in protocols and outcome measures has made it difficult to determine the most appropriate measures to use for assessing the impact of mCIMT. One possibility for why these outcome measures have not yet been compared is due to the varying protocols. Another possible reason is that they measure different things. Since research of mCIMT is young, the best dependent variables are still being sought, thus explaining the appearance in the literature of a variety of outcome measures and protocols.

Occupational therapists have used mCIMT in a camp format for pediatric populations (Bonnier, Eliasson, & Krumlinde-Sundholm, 2006), which has presented challenges due to the short duration of the camp. The effectiveness of mCIMT must be determined in a matter of days or weeks, so outcome measures need to be readministered shortly after initial evaluation and sensitive enough to detect subtle changes in function. In addition to sensitivity, ease of administration and complexity of scoring, as well as reliability and validity, are some of the important considerations in choosing an outcome measure for a mCIMT camp. A balance between these criteria is essential in selecting the instrument(s) to determine the effectiveness of the intervention and a factor in selecting the most effective outcome measure for mCIMT.

The need for determining a balance of criteria for selecting outcome measures became evident during a recent mCIMT summer camp (L. Berg, personal communication, September 24, 2012). The current study was designed to assist in identifying outcome measures for a camp that is three weeks in duration with six hours of constraint Monday thru Friday. Children attended camp sessions for three hours per

day and were required to wear the constraint for an additional three hours at home (L. Berg, personal communication, September 24, 2012). The constraint was a removable, flexible fiberglass material applied from fingertip to mid-humerus that maintained each child's arm at $\sim 90^\circ$ elbow flexion and neutral pronation/supination at the forearm (L. Berg, personal communication, September 24, 2012). There was no prescribed home program for the three hours of constraint at home, however, suggestions for active functional use of the involved upper extremity were given to each family. Outcome measures used in this camp were done as pre- and post-test. They included PROM of the upper extremity, dynamometry, lateral pinch measured by pinchmeter, length and girth measurements of the arm, hand, and forearm in centimeters, Mallet photos, which are a group of photos to identify range of motion movements for nerve involvement from C1-C8 (Blaauw, Muhlig, Kortleve, & Tonino, 2004), and parent/child report of deficits and goals (L. Berg, personal communication, September 24, 2012). Camps such as this one that need to select instruments would benefit from a quick reference to determine which instruments best measure mCIMT.

Background

CIMT began as a treatment approach for adults with hemiparesis as a result of Taub et al.'s (1994) theory of learned nonuse, the inclination to not use an impaired limb following an injury, and neuroplasticity, the ability of the brain to reorganize and send signals to the body via a different path (Deluca, Echols, Law, & Ramey, 2006). In traditional CIMT, the constraint is worn between six hours and 90% of the waking day with repetitive training of the involved upper extremity (Hoare et al., 2009). Some models of traditional CIMT include six to seven hours of training per day over the course of two to three weeks (Deluca et al., 2006). Eliasson, Krumlinde-Sundholm, Shaw, and

Wang (2005) suggest the intense nature of traditional CIMT is not practical for children or their caregivers and reduces the opportunity for children to learn in a natural setting, such as their home or school.

In order to better facilitate children's needs, the frequency and duration of traditional CIMT has been modified (Gordon, Charles, & Wolf, 2005). A number of variations are used in mCIMT and CIMT, from an hour or two a day, every day for a number of weeks or months to a camp schedule of three to six hours a day for 21 days (Deluca et al., 2006; Eliasson et al., 2009; Gordon et al., 2011; Hoare et al., 2009). The type of constraint used in mCIMT frequently is different. Constraints range from a hand puppet worn during camp activities (P. Coker, personal communication, February 2, 2012) to a bivalve cast with continuous constraint for the duration of therapy (Case-Smith et al., 2012). The type of constraint can also impact the wearing schedule. Despite differences in constraint protocol, activities that are done while wearing the constraint generally have intrinsic motivation for the pediatric population to promote use of the affected arm (Case-Smith et al., 2012; Deluca et al., 2006).

A number of studies have been done using mCIMT for children with varying diagnoses including hemiparesis as a result of cerebral palsy or stroke. Some overlap exists in the outcome measures used in these studies; however, overall there is no consistency. The lack of a consistent outcome measure is likely due to the differences in mCIMT protocol and specific performance skills being measured.

Sakzewski et al. (2010) found a strong positive relationship between unimanual training of the affected extremity and bilateral performance using the MUUL and the AHA in 70 children between 5 and 16 years old with congenital hemiplegia. In spite of this, Sakzewski et al. (2010) were unable to determine the direction of any causal

relationship, meaning they could not determine if increased unimanual skill resulted in increased bilateral performance or if the opposite was true. There is also the possibility that both increased together as a result of a third unidentified cause, possibly the therapeutic activities performed during the period of constraint.

Taub et al. (2004) found improvement on the Emerging Behavior Scale (EBS), the PMAL, and the Toddler Arm Use Test (TAUT) during a randomized controlled trial for children with hemiparesis from cerebral palsy. In a randomized crossover trial, Deluca et al. (2006) found significant changes in upper extremity use in 18 children aged 7 to 96 months after 21 days of constraint with six hours of active treatment per day. These findings were determined using the Quality of Upper Extremity Skills Test (QUEST), the PMAL, and the EBS and changes remained at a 6-month follow up (Deluca et al., 2006). Using a similar protocol, Case-Smith et al. (2012) found increased use of the affected upper extremity in children receiving three hours or six hours of active treatment per day that also remained at a 6-month follow-up. Although the protocols were slightly different, both studies used the QUEST and the PMAL as outcome measures. Case-Smith et al. (2012) also used the AHA, which showed significant improvement for both groups (three and six hours per day) after pediatric CIMT treatment.

Eliasson et al. (2009) in Stockholm, Sweden also used a camp model for mCIMT. The two-week day camp model (total of 63 hours) with 16 participants with congenital hemiplegia (5 of whom received intramuscular botulinum toxin type A (BoNT-A) 2-weeks before to muscles identified as inhibiting functional movement) used the MUUL, the AHA, the JTHFT, and specific trained tasks to determine the impact of the camp (Eliasson et al., 2009). Benefits of the camp were seen on the MUUL for those receiving

BoNT-A before camp and on the JTHFT for those children only receiving mCIMT, but not on the other assessments (Eliasson et al., 2009). In this case the outcome measures may not have been sensitive enough for test-retest with the two-week time period of the camp, even though the overall hours were similar to those in other studies.

Aarts, Jongerius, Geerdink, van Limbeek, and Geurts (2011) used goniometry (both AROM and PROM measurements) and video analysis measures developed specifically for their study. The Video Observations Aarts and Aarts module Determine Developmental Disregard (VOAA-DDD) is an outcome measure developed to determine developmental disregard, capacity and performance of the affected arm (Aarts et al., 2011). Results showed a noteworthy increase in capacity for children receiving mCIMT compared to a group of children receiving usual care, as well as a trend toward increased active wrist extension (Aarts et al., 2011). These measures have yet to be used elsewhere in studies; however, they are similar to those in other studies since they were based on goniometry and video analysis of the amount and quality of movement of the affected arm.

In a systematic review evaluating CIMT, mCIMT, and Forced Use protocols, Hoare et al. (2009) found a statistically significant effect of mCIMT for a single trial. There were 26 prospective studies identified, however, only three studies met the inclusion criteria for the review, with one study per protocol. The review included randomized controlled clinical trials (RCT) and clinical control trails (CCT) with participants aged 0-19 years with hemiplegic cerebral palsy (Hoare et al., 2009). Dependent variables used in the studies were categorized as measuring physical, activity, and participation levels. As with other studies, the AHA, the QUEST and the PMAL were identified, as well as the TAUT, the Wolf Motor Function Test (WMFT), the

Canadian Occupational Performance Measure (COPM), Goal Attainment Scaling (GAS), the Peabody Developmental Fine Motor Scale, the Pediatric Evaluation of Disability Inventory (PEDI), the Box and Block Test, and the WeeFIM (Hoare et al., 2009). This list of outcome measures established by Hoare et al. (2009) shows the variety used to assess the effectiveness of mCIMT and CIMT between 1980 and August of 2006.

Another systematic review identified outcome measures to assess arm movement in children with hemiplegic cerebral palsy (Klingels et al., 2010). Klingels et al. (2010) identified 11 outcome measures for use with this population to determine what children are able to do with the affected arm. Similarly, Greaves, Imms, Dodd, and Krumlinde-Sundholm (2010) conducted a systematic review of assessments of bimanual performance in children with hemiplegic cerebral palsy. Only one outcome measure, the AHA, met inclusion criteria for both studies. Greaves et al. (2010) found the AHA to be the only reliable and valid tool in the 11 outcome measures assessed. Sakzewski, Boyd, and Ziviani (2007) reviewed seven outcome measures of participation for children with cerebral palsy that could be administered via postal mail. None of the outcome measures in this study overlapped with those in the other systematic reviews, however, the purpose of the included assessments was different: participation compared to arm use. Reliability, validity, and responsiveness of the tools in this study were reported with GAS and the COPM as the only tools to show good responsiveness (Sakzewski et al., 2007).

Klingels et al. (2008) compared the MUUL and the QUEST with a group of children in the overlapping age range of the measures (5 to 8 years) with hemiplegic cerebral palsy. These two outcome measures were correlated with other pediatric

outcome measures, which established concurrent validity (Klingels et al., 2008). The QUEST is correlated with the Peabody Developmental Fine Motor Scale and it evaluates the upper extremity movement of children between 18 months and 8 years old (DeMatteo et al., 1993). The MUUL was developed for children age 5 to 15 years and is correlated with the PEDI (Bourke-Taylor, 2003). Klingels et al. (2008) determined after administering both the MUUL and the QUEST to 21 participants that both tests are reliable measures of unilateral upper extremity function, and had a high correlation to one another. However, upon inspection of the content of each test, Klingels et al. (2008) identified different aspects of upper extremity function as the construct measured. The QUEST examines aspects of body function, including gross motor movements, while the MUUL is an activity-based assessment to determine fine motor and functional skills (Klingels et. al, 2008).

The use of mCIMT in pediatric populations has increased and most studies show positive results, but more research is needed to better quantify the outcome from mCIMT. Studies are needed using a consistent protocol and outcome measures in order to permit comparison of data from multiple studies. Determining the most appropriate outcome measures is an important aspect of the study design, including the feasibility and sensitivity of the outcome measures. Reliability, validity, and ease of administration and scoring are also considerations for choosing an outcome measure. It is especially important for occupational therapists providing mCIMT in a camp format to use the most effective outcome measure due to the limited time involved. As Eliasson et al. (2009) found, some camps may have too short a duration for the outcome measures used. An appropriate outcome measure for a mCIMT camp will have good feasibility, reliability and validity for the age range of the participants, will be sensitive

enough for the timeframe of the camp, and be easy to administer and score. Therefore, the purpose of this study was to determine the most appropriate outcome measures for two groups of children ages 4-7, 8-12 (younger and older) with upper extremity hemiparesis resulting from various diagnoses participating in a three week modified constraint-induced movement therapy (mCIMT) camp.

Method

Research Design

A two-phase systematic literature review was used to identify and evaluate the outcome measures of interest in the current study. Phase one consisted of identifying the instruments to be included in the study, and phase two the evaluation of the instruments identified in phase one.

Procedure

For phase one, a review of the literature was conducted using Medline, CINAHL and OT BiBSys covering January 1, 1985 through May 31, 2012 to determine the outcome measures used in mCIMT studies. Those included in the review had to be from a peer reviewed scholarly journal. Limits were set on the search to include articles written in English, with human subjects and participants 0-18 years of age. Articles were then screened to determine which studies had child participants with one-sided weakness, including obstetric brachial plexus palsy, cerebral palsy, and hemiplegia resulting from stroke. Articles were excluded if participants underwent surgical management, such as hemispherectomy, electrical modalities or their injuries were the result of a traumatic brain injury (TBI). Due to limited studies including participants with obstetric brachial plexus palsy, this diagnosis was excluded after phase one. Outcome measures that were standardized and appeared in at least two of the articles were

selected (see Figure 1). These outcome measures were then classified using the Occupational Therapy Practice Framework (OTPF) (American Occupational Therapy Association, 2008) as measuring: Performance Skills, Areas of Occupation, or Body Function.

Phase two of the review began with a search using Medline, CINAHL, OT BiBSys, PsychLit, and ERIC to locate literature that has been published on these outcome measures. Administration manuals were also used to help determine the usefulness of assessments based solely on the criteria below. Outcome measures without published literature were assessed based on the administration manual.

Specific outcome measures included in the review were individually searched in the above databases to identify research about them. The original search was limited to children (birth to 19 years old), human subjects, and published in English. Abstracts were assessed to determine if the article identified psychometric properties for the outcome measure and met the target age range and diagnosis. Articles reporting on use of outcome measures for lower extremity testing in children with cerebral palsy were excluded, since this study was concerned with the upper extremity. Since data were not available for all outcome measures specific to a pediatric population, the search was expanded to include all ages and disabilities for outcome measures originally designed for a broader population. Outcome measures using information from this broader population are noted in the results. In some cases, multiple articles reported different values, in which case a range was assigned to that particular outcome measure.

Data Analysis

Once the data were collected, the outcome measures were analyzed based on the criteria below:

- Purpose/what is the test assessing (construct being measured)
- Target population (including designated age range and diagnosis)
- Reliability
 - Test-Retest Reliability
 - Inter-Rater Reliability
 - Intra-Rater Reliability
- Validity
 - Face Validity
 - Content Validity
 - Concurrent Validity
 - Construct Validity
- Ease of use/Time needed to administer
- Credentials to administer test
- Mode of administration
- Time restrictions for test/retest
- Sensitivity
- Specificity

After identifying the characteristics of each outcome measure based on the above criteria, the assessments were compared using a chart, as explained below. Criteria identified above were scored on a scale of zero to two points for each outcome measure. Purpose of the test, credentials needed to administer the test, and the mode of administration were recorded but not scored, as these criteria do not easily fit into a quantitative point system (see Figure 2). The range of time needed, in the case of administration and scoring, and scores for all outcome measures was taken and divided

into three sections. Items falling in the bottom third of a category receive a zero. Items in the middle were scored a one and those in the top third were given two points. For cases where a range of scores was available for an outcome measure, the range was averaged and used to determine points. If the information was not available for an outcome measure it received a zero in the category due to lack of data. If data were available for an adult population, but not yet for a pediatric population, the outcome measure received one point for that criterion if it was in the top two thirds of the range. For example, in Figure 3, the range of inter-rater reliability was from 0.22-0.99 making 0.77 points between the most and least reliable. This number was taken and divided by three to determine the ranges for the top (0.99-0.73), middle (0.72-0.47), and bottom (below 0.46) thirds. The outcome measures were then given scores based on where the inter-rater reliability fell within these ranges, two points for the top third, one point for the middle third, and no points for the bottom third. This was then repeated for the remaining criteria.

Measures with target populations meeting the age range and diagnoses for a camp for children ages 4 to 12 years old were given two points. If the outcome measure covers part of the age range, it was given one point. Outcome measures that do not cover any of the target age range were given no points. A score was then given for each outcome measure in the areas of target population and administration (category total 8 points, see Figure 2), reliability and validity (category total 12 points, see Figure 3), and an overall score combining these two data sets (total 20 points, see Figure 4).

Information from the figures was then analyzed to determine the most appropriate outcome measures to assess two groups (younger and older) of children 4-7 and 8-12 years old used for a mCIMT camp with a duration of three weeks.

Results

Phase 1

A total of 27 articles were found meeting the original criteria. Articles included randomized control trials (7), randomized clinical trials (2), controlled clinical trials (4), outcome studies (5), and case studies (9). Of these articles, three had participants diagnosed with obstetric brachial plexus palsy. These were excluded due to the scarcity of data for this population. Forty outcome measures were identified from the remaining 24 studies. Dickerson and Brown (2007), Glover, Mateer, Yoell, and Speed (2002), and Smania et al. (2009), were eliminated because the outcome measures were specific to the individual studies and did not appear in any other study. A total of 21 studies were used to identify outcome measures and they included randomized control trials (7), randomized clinical trials (2), controlled clinical trials (3), outcome studies (4), and case studies (5). Seventeen outcome measures were identified as being in more than one of the 21 studies to measure the impact of CIMT (see Figure 1). Based on what they assess, the outcome measures identified for review were grouped by OTPF into Areas of Occupation (5), Performance Skills (8), and Body Function (4) (American Occupational Therapy Association, 2008).

Outcome measures identified (see Figure 1) as Areas of Occupation were addressed by the ABILHAND- Kids, the Canadian Occupational Performance Measure (COPM), the Emerging Behavior Scale (EBS), Goal Attainment Scaling (GAS), and the Pediatric Evaluation of Disability Inventory (PEDI). Although the PEDI was only used in one of the studies included, it remained a part of this study due to its concurrent validity with other measures. Performance Skills included the Assisting Hand Assessment (AHA), the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), the Jebsen-Taylor

Hand Function Test (JTHFT), the Melbourne Assessment of Unilateral Upper Limb Function (MUUL), the Peabody Developmental Motor Scales, First and Second Editions (PDMS-2), the Pediatric Motor Activity Log (PMAL), the Quality of Upper Extremity Skills Test (QUEST), and the Toddler Arm Use Test (TAUT). Outcome measures addressing Body Function include both active and passive range of motion (AROM and PROM) through goniometry, grip strength with a dynamometer, the Modified Ashworth Scale (MAS), and the Modified Tardieu Scale (MTS) (see Appendix for citations).

The articles included in the review may have utilized additional outcome measures in their studies, however, these other outcome measures were not included due to the exclusion criteria. Studies using either the first or second edition of the same test, as was the case for the Peabody Developmental Motor Scales, were combined for the criteria of being used in more than one study. Overall, the AHA, a Performance Skill measure, was used most often (9 studies) in the included studies to measure the impact of pediatric mCIMT. The AHA was followed by the PMAL (8 studies) and the JTHFT (7 studies), which are also Performance Skill measures.

Phase 2

Psychometric data for 17 outcome measures were researched. The first edition of the Peabody Developmental Motor Scales was excluded, since the second edition of this test is currently used. Two other outcome measures were removed from the results during Phase Two, the Toddler Arm Use Test (TAUT) and the Emerging Behaviors Scale (EBS), due to lack of psychometric data available. Both tests have been revised and renamed, the Pediatric Arm Function Test (PAFT) and the Inventory of New Motor Activities (INMA), respectively (Taub et al., 2007).

Of the remaining 15 outcome measures, only five had data available on sensitivity (see Figure 2), however, sensitivity was not consistently measured in all five outcome measures. Content and construct validity were established in pediatric populations for many of the outcome measures, although quantitative data were not available for the majority of the outcome measures (see Figure 3). Due to this, outcome measures that established validity in children were only given two points if quantitative data were available.

Test-retest time restriction could not be found for any outcome measures. Specificity was only found for grip strength measured with a dynamometer (66.7%-72.5%)(van den Beld, van der Sanden, Sengers, Verbeek, & Gabreëls, 2006). Ease of use was also not reported consistently among outcome measures. Therefore, these three criteria were removed for the purposes of scoring.

Outcome measures testing Performance Skills showed the highest reliability and validity with a range of 7-11 of 12 points (see Figure 3), but scored lower on correct age range and diagnosis and administration time (see Figure 2). Those testing Body Function had scores ranging from 3-7 of 12 points for reliability and validity (see Figure 3), but scored higher on age range, diagnosis, and administration time (see Figure 2). The JTHFT, the MUUL, and the QUEST all scored 11 of 12 points for reliability and validity, while the highest scoring outcome measure in Body Function was goniometry with 7 of 12 points (see Figure 3). Areas of Occupation outcome measures scored lowest for correct age range and diagnosis and administration time and in the middle for reliability and validity (see Figure 4).

The AHA, which was used most often in the research (9 of 21 studies), established good reliability and validity in a pediatric population, but was the only

outcome measure assessed that required extensive training before administration. Other outcome measures recommended training, such as the MUUL and the QUEST, but did not have specific requirements.

Discussion

This study was an attempt to compare outcome measures used for pediatric mCIMT in a camp setting. An appropriate outcome measure for a mCIMT camp will have good reliability and validity for the age range of the participants, be simple to administer and score, and be sensitive enough to detect change in a short timeframe. Reliability and validity reported are similar to those reported by Greaves et al. (2010), Klingels et al. (2010), and Sakzewski et al. (2007). Differences may have arisen because the current review included other studies not used by the other three reviews. Outcome measures assessing Areas of Occupation, ABILHAND-Kids, COPM, GAS, and the PEDI, were overall reliable and valid, with the ABILHAND-Kids and the PEDI scoring highest in this group, followed by the COPM. The COPM and GAS take longer to administer and have lower reliability and validity, however these two measures did show sensitivity to change.

Performance Skills were measured by seven outcome measures included in this study: AHA, BOTMP, JTHFT, MUUL, PDMS-2, PMAL, and QUEST. These measures proved to be reliable and valid measures of arm use, but scored lower on the age range, diagnosis, and administration time. This indicated that these outcome measures may take longer than those testing Body Function, but are likely more useful in assessing pediatric mCIMT. The AHA, which was used most often in the literature (9 of 21 studies), did score high, but did not have as many points as the JTHFT due to lack of information regarding concurrent validity and sensitivity. The JTHFT scored highest with

16 of 20 points, followed by a three-way tie between the AHA, the MUUL, and the QUEST, all with 14 of 20 points (see Figure 4).

Body Function measures were the least reliable and valid group, but included a broad target population and were often the quickest to administer and score. In this group, grip strength with a dynamometer had the highest score (14 of 20), with goniometry only one point behind (13 of 20) (see Figure 4). MAS and MTS were both quick to administer and cover the entire age range and diagnosis, but were not as reliable or valid.

Overall, the purpose of the measurement influenced which outcome measure to use. The ABILHAND-Kids scored highest for measuring Areas of Occupation, however, the sensitivity of this test was not established, making it difficult to determine the usefulness of the tool for a camp setting. Klingels et al. (2010) identified the ABILHAND-Kids as their choice for a questionnaire. Sakzewski et al. (2007) identified the COPM and GAS as able to identify clinical change, which may be an important quality for assessing a pediatric mCIMT camp with a short duration.

It is suggested by point scores that the MUUL be used for the older group and the QUEST for the younger group to measure Performance Skills. These tests both assess unilateral upper extremity function and do not require the extra training needed for the AHA. The JTHFT scored highest in Performance Skills and is suggested to assess hand function, however, it does not cover the entire age range of the younger group. Greaves et al. (2010) and Klingels et al. (2010) both identified the AHA as a good choice for measuring Performance Skills in children with cerebral palsy. Klingels (2010) also identified the MUUL as a good option.

Grip strength with a dynamometer scored highest for testing Body Function, but outcome measures in this category overall earned lower scores and were not concurrently valid with Areas of Occupation or Performance Skill measures. Measuring range of motion with a goniometer earned a low score for reliability (7 of 12 points), suggesting it may be difficult to accurately measure the range of more complex joints in the upper extremity. Outcome measures testing Body Function were not included by Greaves et. al (2010), Klingels et al. (2010), or Sakzewski et al. (2007). This also brings up the question of how useful these measures are for a pediatric mCIMT camp. The lack of information regarding sensitivity overall may impact the usefulness of outcome measures for a camp setting due to the short time period for test re-test.

It is important to note that recommendations are based on the protocol used for the current study. Outcome measures in this study were given more points for meeting a specific age range (children age 4-12), and for shorter administration and scoring times. Also, some of the outcome measures were not specifically developed for children with upper extremity hemiparesis. This may have an impact on the usefulness of outcome measures identified in this review, since measures not developed for this population may be validated for other populations or be testing different aspects of function. Overall, more research is needed to confirm reliability and validity results for all of the outcome measures. In some cases, small sample sizes were used to determine these values, which could impact the accuracy of them. Sensitivity of outcome measures was only available for a few assessments included in this review. This is an important aspect for use of outcome measures in a mCIMT camp setting due to the short test re-test time. Recommendations may have been different if this information were more widely available.

Future Research

Future studies should attempt to examine sensitivity and specificity for outcome measures to identify whether or not the change being seen is real. Reliability and validity also need to be established in a pediatric population for all outcome measures to accurately compare them. It was difficult to compare outcome measures due to differences in pediatric mCIMT protocols and tool use. In future studies, a more consistent use of outcome measures and protocols could increase the ability to compare effectiveness of outcome measures. Due to the low scores of outcome measures assessing Body Function, a different outcome measure, such as Mallet photos (Blaauw et al., 2004), could be considered to assess this area.

Limitations

Some limitations of this study include using outcome measures that appeared in at least two studies. Other outcome measures may be available that better test the impact of mCIMT that were not used in two or more studies. Another limitation was not all outcome measures had psychometric data available based on mCIMT. This could impact the ability of outcome measures to determine effectiveness of mCIMT, since they may not be as reliable or valid to measure children undergoing a mCIMT protocol. This study was also specific to a camp with two groups of children aged 4-7 and 8-12, which influenced the points given to the measures.

Implications for OT

Based on the protocol used in the current study, occupational therapists should consider using an outcome measure from each category, Areas of Occupation, Performance Skills, and Body Function, to assess different aspects of functioning during a pediatric mCIMT camp. Areas of Occupation are assessed by the ABILHAND-Kids,

which is a questionnaire that can be quickly administered and identifies tasks a child may have difficulty with. This outcome measure may not be sensitive enough to identify change over a short period of time, but was also recommended by Klingels et al. (2010). The COPM and GAS take longer to administer, but were sensitive to change over a short period of time. For Performance Skills, the MUUL and QUEST assess unilateral upper extremity function and cover the age range of the two groups (4-7 and 8-12 years old). The JTHFT assesses hand function, but does not cover the entire age range. The AHA covers the age range and assesses a child's ability to use the affected hand to assist in tasks, however, additional training is needed and may not fit time or budget constraints. Grip strength received the most points in the Body Function category and may assist in identifying difficulty in hand function as a result of weakness. Range of motion scored next in the Body Function category, however, inter-rater and intra-rater reliability were low indicating range of motion measurements may not be consistent even when assessed by the same rater.

Conclusion

This systematic review found that there were differences in protocols and outcome measures used for mCIMT, making it difficult to identify and compare measures. Fifteen outcome measures were identified in this review, four measuring Areas of Occupation, seven measuring Performance Skills, and four measuring Body Function. A combination of outcome measures from these categories may be needed to fully assess a child participating in a mCIMT camp. The reliability and validity of outcome measures were established for most measures, however, sensitivity still needs to be established for the majority (13 of 15) of the outcome measures. It is suggested that the ABILHAND-Kids be used for Areas of Occupation, the QUEST and the MUUL,

for younger and older groups respectively, be used for Performance Skills, and grip strength with a dynamometer for Body Function, to assess a child participating in a mCIMT camp for increased consistency in evaluating the effectiveness of a mCIMT camp.

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Study	Areas of Occupation					Performance Skills								Body Function			
	ABILHAND-Kids	COPM	EBS	GAS	PEDI	AHA	BOTMP	JTHFT	MUUL	PDMS/ PDMS-2	PMAL	QUEST	TAUT	AROM/ PROM	Grip	MAS	MTS
Aarts et al., 2010	•	•		•		•			•								
Aarts et al., 2011	•	•		•		•											
Bonnier et al., 2006							•	•							•		
Boyd et al., 2010		•				•			•					•	•	•	•
Case-Smith et al., 2012						•					•	•					
Charles et al., 2007								•							•	•	
Coker et al., 2009										• ²							
Cope et al., 2008										• ²	•		•				
de Brito Brandão et al., 2010					•			•									
DeLuca et al., 2006			•								•	•					
DeLuca et al., 2003										• ¹	•		•				
Eliasson et al., 2005						•											
Gordon et al., 2006							•	•							•	•	
Gordon et al., 2011				•		•		•				•					
Sakzewski et al., 2011						•		•	•						•		
Sakzewski et al., 2010						•		•	•						•	•	
Taub et al., 2007											•			•			
Taub et al., 2011											•			•		•	
Taub et al., 2004			•								•		•				
Wallen et al., 2007		•		•		•			•		•						•
Willis et al., 2002										• ¹							
TOTALS	2	4	2	4	1	9	2	7	5	4	8	3	3	3	6	5	2

Figure 1. Outcome Measures for Pediatric mCIMT. Seventeen outcome measures to assess mCIMT were identified from twenty-one studies.

Note: •¹ indicates first edition, •² indicates second edition

Assisting Hand Assessment (AHA), Active Range of Motion/Passive Range of Motion (AROM/PROM), Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), Canadian Occupational Performance Measure (COPM), Emerging Behavior Scale (EBS), Goal Attainment Scaling (GAS), Jebsen Taylor Hand Function Test (JTHFT), Modified Ashworth Scale (MAS), Modified Tardieu Scale (MTS), Melbourne Assessment of Unilateral Upper Limb Function (MUUL), Peabody Developmental Motor Scales (PDMS), and Second Edition (PDMS-2), Pediatric Evaluation of Disability Inventory (PEDI), Pediatric Motor Activity Log (PMAL), Quality of Upper Extremity Skills Test (QUEST), Toddler Arm Use Test (TAUT)

Outcome Measure	Purpose	Target Population	Credentials	Mode of Administration	Administration	Time to Administer Scoring	Sensitivity	Section Points (of 8 possible)
Areas of Occupation								
ABILHAND-Kids	Measure manual ability in kids with CP	Children with CP 6 yr - 15 yr	None. Parent of child with CP.	Parent Questionnaire	10 min.	N/A	---	5
COPM	Identify performance problems important to clients (client families)	Any disability Any age	None. Recommended OT.	Semi-structured interview	30-45 min. (7-12 min. re-admin)	5 min.	Performance: ES* = 0.83 Satisfaction: ES* = 0.63	4
GAS	Identify client and/or care provider goals	Any disability Any age	None. Self-directed training recommended.	Semi-structured interview	40-60 min. (7-12 min. re-admin)	7 min.	Weighted: ES* = 1.44 Likert: ES* = 1.28	4
PEDI	Assess child's performance in mobility, self care, and social interactions.	Children with developmental delay; 6 mo - 7.5 yr	None. Recommended OT, PT, ST, & other professionals.	Observation or parent interview	45-60 min.	N/A	---	3
Performance Skills								
AHA	Use of affected hand to assist in tasks	Children with hemiplegic or unilateral CP or OBPP 18 mo - 12 yr	3-day cert course approved ratings	Standard assessment with video analysis	10-15 min.	15-30 min.	---	4
BOTMP	Assess fine & gross motor skills	Children with developmental delay 4 yr - 21 yr	OT, PT, adaptive PE teacher or psychologist recommended	Observation. Standardized assessment	40-60 min.	20 min.	---	3
JTHFT	Assess unilateral hand capacity	Children with motor delay 5 yr - 18 yr	Familiarity with test.	Observation of standardized assessment	10-15 min.	N/A	---	5
MUUL	Assess unilateral UE movement	Children with CP 5 yr - 15 yr	Preferably OT trained by author	Video recording	15 min.	15-30 min.	---	3
PDMS-2	Assess interrelated fine & gross motor skill	Children with motor delay 0 yr - 6 yr	Understanding of test statistics. Self-study.	Observation. Standardized assessment	20-30 min for FM	10-15 min.	ES* = 0.20	3
PMAL	Assess parent perception of change in AOU & QOM	Children with CP 7 mo - 8 yr	None. Parent of child with CP.	Parent questionnaire	5-15 min.	3 min.	PMAL-AOU MDC 0.67 PMAL-QOM MDC 0.66	6
QUEST	Assess unilateral UE capacity	Children with CP 18 mo - 8 yr	Training recommended.	Observation/ video	15 min.	15-30 min.	---	3
Body Function								
AROM/PROM with goniometer	Determine range of motion in joints	Any disability Any age	OT, PT. Training in use of goniometer.	Direct observation.	3 min. per joint	N/A	---	6
Grip with dynamometer	Determine grip strength	Any disability 2 yr-adult	OT, PT. Training in use of dynamometer.	Direct observation.	5 min.	N/A	Se = 81%	8
MAS	Assess muscle spasticity	Children with spastic CP 2 yr- 18 yr	OT, PT, doctor, & other professionals.	Direct observation.	2 min. per joint	N/A	---	6
MTS	Assess muscle spasticity	Children with spastic CP 2 yr- 18 yr	OT, PT, doctor, & other professionals.	Direct observation.	2 min. per joint	N/A	---	6

Figure 2. Population and Administration time for Outcome Measures. This figure shows the purpose, target population, administration details, and sensitivity (if available) of the outcome measures in this review along with the section points.

Note: --- (indicates information not available), N/A (no scoring time needed)

*ES 0.2-0.49 considered small, 0.5-0.79 considered moderate, 0.8 or above is considered large

AOU (amount of use), Assisting Hand Assessment (AHA), Active Range of Motion/Passive Range of Motion (AROM/PROM), Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), Canadian Occupational Performance Measure (COPM), CP (cerebral palsy), ES (effect size), Goal Attainment Scaling (GAS), Jebsen Taylor Hand Function Test (JTHFT), Modified Ashworth Scale (MAS), Modified Tardieu Scale (MTS), Melbourne Assessment of Unilateral Upper Limb Function (MUUL), OBPP (obstetric brachial plexus palsy), OT (occupational therapist), Peabody Developmental Motor Scales, Second Edition (PDMS-2), Pediatric Evaluation of Disability Inventory (PEDI), Pediatric Motor Activity Log (PMAL), PE (physical education), PT (physical therapist), QOM (quality of movement), Quality of Upper Extremity Skills Test (QUEST), Se (sensitivity), ST (speech therapist)

Outcome Measure	Reliability			Validity			Section points (of 12 possible)
	Inter-rater	Intra-rater	Test-Retest	Content	Construct	Concurrent	
Areas of Occupation							
ABILHAND-Kids	$R_o = 0.94$	---	$R_o = 0.91$	yes	yes	Grip strength R_o 0.56	8
COPM	ICC 0.67-0.69	---	0.76-0.89 ^b	yes	yes a 0.86-0.88	GAS ^f R_o 0.35 – 0.49	6
GAS	ICC 0.64-0.82	ICC 0.96	---	yes	---	PEDI R_o 0.28-0.64	5
PEDI	ICC 0.99	---	ICC 0.91-0.98	yes	yes	Melbourne ^f R_o 0.72-0.94 SHUEE R_o 0.47	8
Performance Skills							
AHA	ICC 0.97 -0.98	ICC 0.99	ICC 0.98 - 0.99	yes	yes a 0.96-0.97	---	10
BOTMP	R_o 0.94	R_o 1.00 ^a	R_o 0.86	yes	yes	---	9
JTHFT	R_o 0.99	R_o 0.99 ^a	R_o 0.99	yes	yes	SHUEE R_o -0.76	11
MUUL	ICC 0.95-0.99	ICC 0.97	ICC 0.97-0.98	yes	yes	PEDI ^f R_o 0.94	11
PDMS-2	ICC 0.98 R_o 0.94-0.99	---	ICC 0.99 R_o 0.84-0.98	yes	yes	QUEST R_o 0.84	9
PMAL	ICC 0.90 ^b	---	ICC 0.93-0.94	yes	yes	WeeFIM-SE, WeeFIM, PDMS-2-FM ^f R_o 0.32-0.48	7
QUEST	ICC 0.90-0.96	ICC 0.69 - 0.89	ICC 0.95	yes	yes	PDMS-2-FM R_o 0.84	11
Body Function							
AROM/PROM with goniometer	ICC 0.25-0.91	ICC 0.81-0.94	---	yes	yes ^{ba}	Digital Incliniometry ^b ICC (3, k) 0.85-0.97	7
Grip with dynamometer	---	ICC 0.98-0.99	ICC 0.92-0.99	yes ^b	yes ^b	---	6
MAS	ICC 0.41-0.89 k 0.51	ICC 0.26-0.66 k 0.64	ICC 0.36-0.90	yes	---	---	3
MTS	ICC 0.22-0.85	ICC 0.54-0.95	ICC 0.62-0.83	yes	---	---	3

Figure 3. Reliability and Validity of Outcome Measures. This figure shows the reliability and validity of the outcome measures along with the section points.

Note: --- (indicates information not available), a (Cronbach's alpha), ICC (intraclass correlation coefficient), k (Kappa value), R_s (Spearman rho correlation coefficient), R_p (Pearson correlation coefficient)

^aEstablished using video recording

^bEstablished in adults

^cSelf-care portion of PEDI

^dFor PMAL-QOM only

^eNot established at all joints

^fFor performance section of COPM

Assisting Hand Assessment (AHA), Active Range of Motion/Passive Range of Motion (AROM/PROM), Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), Canadian Occupational Performance Measure (COPM), FMP (Fine Motor Precision), GMFCS (Gross Motor), Goal Attainment Scaling (GAS), Jebsen Taylor Hand Function Test (JTHFT), Modified Ashworth Scale (MAS), Modified Tardieu Scale (MTS), Melbourne Assessment of Unilateral Upper Limb Function (MUUL), Peabody Developmental Motor Scales, Second Edition (PDMS-2), Pediatric Evaluation of Disability Inventory (PEDI), Pediatric Motor Activity Log (PMAL), Quality of Upper Extremity Skills Test (QUEST)

Outcome Measure	Population/ Administration	Reliability/ Validity	Total Points (of 20 possible)
Areas of Occupation			
ABILHAND-Kids	5	8	13
COPM	4	6	10
GAS	4	5	9
PEDI	3	8	11
Performance Skills			
AHA	4	10	14
BOTMP	3	9	12
JTHFT	5	11	16
MUUL	3	11	14
PDMS-2	3	9	12
PMAL	6	7	13
QUEST	3	11	14
Body Function			
AROM/PROM with goniometer	6	7	13
Grip with dynamometer	8	6	14
MAS	6	3	9
MTS	6	3	9

Figure 4. Scores for Outcome Measures. This figure shows the section and total points for all outcome measures in the review.

Assisting Hand Assessment (AHA), Active Range of Motion/Passive Range of Motion (AROM/PROM), Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), Canadian Occupational Performance Measure (COPM), Goal Attainment Scaling (GAS), Jebsen Taylor Hand Function Test (JTHFT), Modified Ashword Scale (MAS), Modified Tardieu Scale (MTS), Melbourne Assessment of Unilateral Upper Limb Function (MUUL), Peabody Developmental Motor Scales (PDMS), and Second Edition (PDMS-2), Pediatric Evaluation of Disability Inventory (PEDI), Pediatric Motor Activity Log (PMAL), Quality of Upper Extremity Skills Test (QUEST)